Engineering Case Library

ECL 8R*

Hiring Engineers and Draftsmen at Task Corporation

The examination attached as Exhibit 3 is used as part of the screening procedure for hiring engineers and draftsmen at Task Corporation of Anaheim, California. In addition to this examination, an applicant is judged on the basis of data given on an application form, a sample of which is attached as Exhibit 1, and personal interviews with Task engineers. Task engineers do not know of any other company which uses such an examination in screening applicants, but think the test is a most useful part of the overall procedure which they describe as "good though not perfect". There has been only one instance of having a new employee work poorly on the job after scoring well on the test.

Prepared in the Design Division, Department of Mechanical Engineering, Stanford University by Karl H. Vesper with cooperation and information from Task Corporation.
*Revised June 1968 by Richard C. Bourne.

The Company

Task is a relatively small company of only 140 employees, but manufactures a wide range of products, including electric motors, pumps, fans, blowers, refrigeration systems, flexure joints, and wind tunnel balances.* Illustrations of these products appear in Exhibit 2. Electric motors, ranging in horsepower from fractions to hundreds, account for the largest share of Task's sales. A special capability of the company is making motors very high in power relative to weight and size. Many of the motors are for aircraft applications, such as running pumps in aircraft and missiles, where extremely high reliability is absolutely essential. To assure that close tolerances are held with high regularity, the quality control department of the company performs 100% inspection on missile motor parts.

Products of Task are generally quite expensive. Many are made for special applications where small quantities are required. Consequently, production runs are often short, requiring that costs of engineering, tooling, setups, and learning be recovered on only a few units. Engineering costs are often high because many special applications impose extremely difficult constraints. One job, for instance, required design of a 240 HP, air-cooled, continuous duty electric motor weighing less than 190 pounds. The careful machining needed to hold close tolerances, and careful quality control required to insure reliability are also expensive. Assembly usually requires a high proportion of hand labor, particularly on the balances, each of which has to be individually assembled and calibrated by a skilled technician. Materials often must be bought at premium prices to assure top quality. Thus a combination of factors push upward the cost of Task products. One of the company's balances weighing only 1/4 pound sells for $15,000.

The high cost of each unit, and the limited quantities of production mean that each product must be carefully engineered. It is too expensive to make

*A wind tunnel balance is a device for simultaneously supporting a model to be tested and measuring forces acting on the model. The balance must be structurally strong so the model will not be torn loose by wind and yet sensitive to the forces. Strain gauges in the balance measure forces about various axes and they must be placed with great skill so the torques and forces can be separately resolved in magnitude and direction.

numbers of prototypes to shake out "bugs". Furthermore, there generally is not time for much "shaking out," since most of the motors are used on special projects running on tight time schedules. There often isn't time to send motors "back to the drawing boards." Drawings must be as right as possible the first time.

Draftsmen work with Task engineers in preparation of designs. Responsibility for correctness of drawings, however, lies primarily with the engineers. Mr. Elmer Ward, President of Task and effectively the company's Chief Engineer, commented on engineering drawing responsibilities as follows: "We encounter engineers who want to stay away from the drafting board, who think they should just be able to make rough sketches and turn the rest over to somebody else. But we can't get good work that way because this approach forces the majority of detail decisions down to less qualified and less responsible individuals. We have to require engineers here to make layout drawings which include all critical details and tolerances. The draftsman then makes more formal manufacturing drawings. But the engineer must go over these drawings and approve them before they are considered finished."

Engineers' responsibility for follow-through at Task goes beyond completion of drawings. Unlike some larger companies where separate specialists write proposals, perform analytical work, design parts, make layouts, and shepherd prototypes through the shop and testing, each Task engineer typically works his project through all these phases.

The pay of engineers at Task is not especially high, and the hours are often long, but the company does not have difficulty keeping some highly competent men and turnover is low. Typically, many of the engineers do not leave promptly at quitting time, and occasionally they work very late preparing proposals or solving knotty problems. One of them commented as follows: "I could work shorter hours and make more money at one of the big companies, but I don't think I'd enjoy it or learn as much. Here I'm not confined to a narrow specialty. I not only work on technical problems, but I get in on sales and also work with the men in the shop as well. The main thing though, is that here I can carry a project all the way through from the concept to working hardware and that, to me, is satisfying."

Mr. Randy Winters, Task's Production Manager, commented on the company's organization as follows: "We have tried not to organize more than we absolutely had to. We avoided making any organizational charts or job descriptions, hopefully to prevent the occurrence of what every organization seems to strive for, that is, running down hill toward internal stability. Both our workload and our products are subject to so much variation that we can't afford to have people whose jobs are so well defined that they just do certain things in the way of work and then conclude that they are all finished. So much of our work is on a custom order basis that we have to be able to move people around. Some of our people who would normally be on salaries in most companies are on hourly wages here. If they were on salaries they would be less willing to come in to work on Saturdays when the workload is up.

"Our way of operating is frustrating to many people when they first join us. We give them freedom they haven't been used to elsewhere and they feel less secure. When we move them around they get nervous. But if they can hang on for a while, they find out how much they can get done and then they begin to relax.

"In many engineering problems there is no orderly approach that will work, and it is impossible to plan so that everyone can just work along smoothly. The only time we get superior results is when we have to have them; and this usually happens at the last minute. This process may be uncomfortable, but we think it is relatively efficient because we generally get the answer we want the first time around, and we have solved a lot of problems that the big companies couldn't handle. Recently we beat a big company that wanted six months and $50,000 for a certain type of motor. We built it in one month for $23,000. This big company was probably just like several of them that have the pressure so low they are virtually paralyzed. They have huge rooms full of engineers who can't get anything done. We sometimes wonder how they survive.

Mr. Ward shared Mr. Winters' enthusiasm for Task's engineering design abilities, commenting as follows: "I once made an offer to a prospective customer that he could either give us his motor problem, or he could give it

to any other company and then show us the motor they came up with, and if we couldn't sketch out a better design in one hour I would pay him a hundred dollars. I have noticed advertisements in trade publications by several of the larger electric motor companies boasting that they use a computer to design their motors which is capable of evaluating several thousand designs in an hour to select the best design. But my hundred dollar offer still holds. Our motor design methods permit us to optimize a design as we go along, and it also allows us to apply judgment about many more variables than the computer can possibly consider.

"About three years ago we started making a tiny motor for a company which will use it in running a calculator. The calculator required a motor which was very small, but quite high powered. The calculator company had one prominent motor company make a motor for the need, but the most powerful motor they were able to make within the required size proved to be not powerful enough to run the machine. After seeking help from all the motor companies they knew, and finding that none of them could do the job, the calculator company sent a scatter letter to all the companies they could find who might be able to help them. We happened to get one of their letters, undertook to solve the problem, and did. Our motor was within the required size limits and gave twice the required power. The customer has since been trying to find another company able to make an equivalent motor as a second source of supply, but without success so far."

The Dimensioning Test

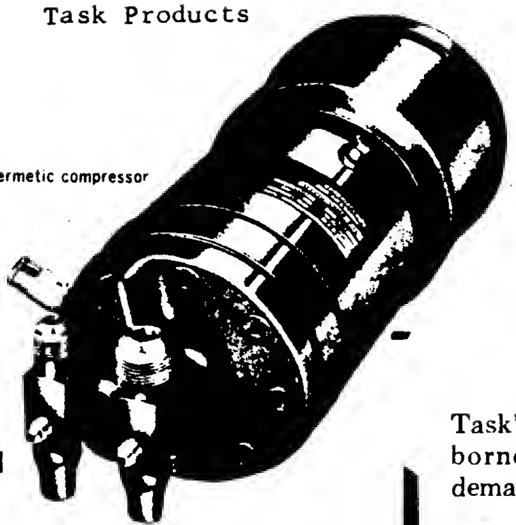
The importance of correctness in engineering drawings prompted Mr. Richard Rigney, a Task engineer, to prepare the dimensioning test which is attached as Exhibit 3. He noted that some of the most annoying problems of prototype machines that didn't work were caused by improper fits of finely finished and expensive parts. The source of the difficulty he often traced to dimensioning, not correctly stated on blueprints to give the desired fits and clearances. To correct the situation, he proposed that draftsmen and engineers be given a proficiency test on dimensioning. In the test he has included the sorts of problems which seemed to give the most difficulty.

No attempt has been made to include tricks or hidden traps in the problem. Mr. Rigney believes, however, that the test indicates more than merely ability at dimensioning, classifying it as "really sort of a simple intelligence test."

Mr. Ward also sees it as more than simply a dimensioning test, saying that its broader function is to test a man's attentiveness to details in general. "Attention to details is something more engineers need to learn," he said. "Its not enough to do a good job of 'big picture' thinking on designs. We always get that right. Our real 'bugaboos' are the small things we overlook. People can easily be fooled on 'paper designs' but you can't fool hardware It reacts exactly according to the design, details included."

The dimensioning test is given to an applicant with the injunction that he read the instruction sheet <u>carefully</u>, and do exactly what it says and nothing else. Both draftsmen and engineers are given the test, and typically the scores of one group have been about the same as those of the other. A normally acceptable performance, according to Mr. Rigney, is to make about two or three mistakes. There is no limitation set on time, but it has been observed that those men the company hired had usually finished in 15 minutes or less.

Task Products



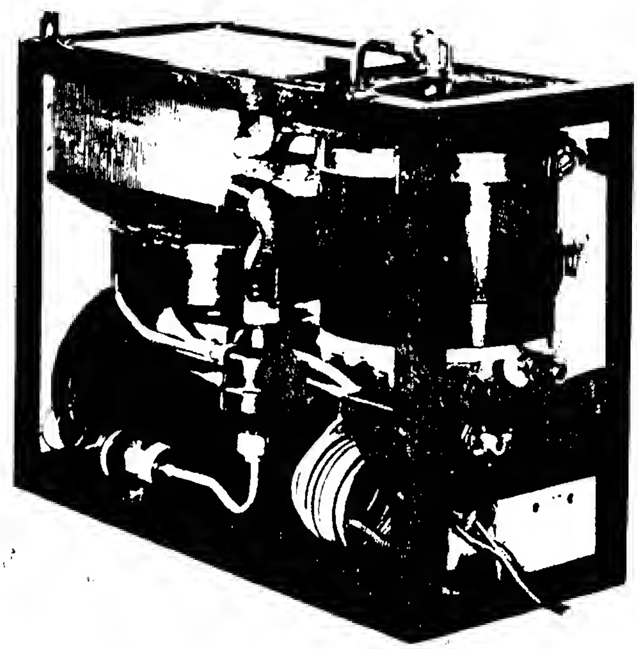
9½ hp hermetic compressor

THE TASK APPROACH

Behind the development of the Task Refrigeration-Condensing Unit are nearly two decades of specialized research and design. By breaking away from long-standing traditions, Task engineers have uncovered new packaging approaches and design concepts resulting in exceptional weight and space saving characteristics while greatly increasing reliability.

In airborne refrigeration or any related field, Task is ready to design and build to specific customer requirements. Whatever your problem, no matter how complex your application, Task techniques can be adapted to quick, efficient and economical production.

Task's new compact water cooler, designed for airborne use, answers airline problems of passenger demand while reducing costly ground servicing.



Developed specifically for airborne applications, Task's new high efficiency refrigeration-condensing units achieve the important combination of weight saving and versatility. One-half and one-quarter horsepower sizes are currently being manufactured in both horizontal and vertical units. Either type can be mounted in confined spaces in sidewalls or under floor areas, thereby increasing space utilization in the airframe or air transportable vehicle.

Each unit contains a hermetically sealed compressor, a condenser with co-axial receiver tank and a fan mounted between the compressor and condenser.

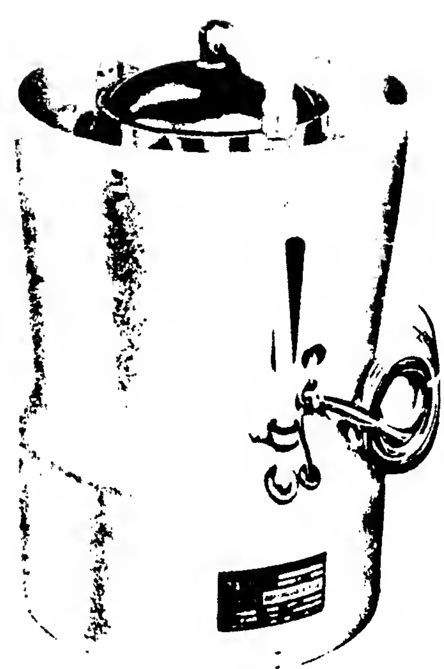


Exhibit 1

ECL 8R

Start Date ____________ Rate $ ________ Emp. # ________ Appr. ________

Ap·lication for Employment

TASK CORPORATION
1009 East Vermont Ave., Anaheim, Calif.
PRospect 4-3100

Date ____________ Time ___:___ AM/PM

M ____________ ____________ ____________
Last Name First Name Middle Name

____
Kind of Work Desired

When could you start to work? ____________

Address ____________ City ____________

____
Social Security Number

PERSONAL STATUS			GENERAL INFORMATION
Single ☐	Separated ☐	Own/Buying home ☐	How long at the above address? ____
Married ☐	Divorced ☐	Rent ☐	Telephone Number ____
Widowed ☐	Engaged ☐	Live with Parents ☐	Do you know anyone working here? ____
Number of children ____		Live with Spouse ☐	Names ____
Other dependents ____		Live with relatives ☐	

EDUCATION (name and address)	Circle last grade completed	Graduate?	Date of leaving
Last Elementary School	1 2 3 4 5 6 7 8		
Last High School	9 10 11 12		
Junior College	Major field	Degree:	
College or University	Major field	Degree:	
College or University	Major field	Degree:	

A ional Educational Information

Did you serve an apprenticeship? What Trade? When

Have you ever been refused a bond? When and by Whom

Have you any objection to being bonded if you are employed at Task?

CITIZENSHIP	U. S. MILITARY SERVICE		SECURITY
Are you a citizen of the U.S.A.?	From	To	Have you ever been arrested? ____
Date of birth	Branch	Rank	Explain all charges (except traffic violations for which a fine of less than $25.00 was imposed)
Verified by	Type of discharge ____		
You will be required to show your birth certificate and military discharge if employed at Task	Reserve organization ____		
	Draft classification ____		
	Board ____		
Have you ever failed to pass an insurance physical examination? ____	Do you have any war service disability?		Have you ever been granted or denied a security clearance?
Have you missed work in the past 6 months due to illness?	Do you have any physical Limitations? ____ Explain:		What level When
			Granted Denied By Whom

EMERGENCY NOTIFICATION

EMPLOYMENT RECORD	In this space account for all time for the past 10 years, whether working or not. Include military service and periods of unemployment. Give complete names and addresses. If self employed, give firm name and one business reference.

EMPLOYED From Mo. Yr.	EMPLOYED To Mo. Yr.	EMPLOYER'S NAME AND ADDRESS Start with most recent employer	WHAT DID YOU DO?	WAGE	REASON FOR LEAVING

GIVE THREE REFERENCES, NOT RELATIVES OR FORMER EMPLOYERS, WHOM YOU HAVE KNOWN AT LEAST 5 YEARS

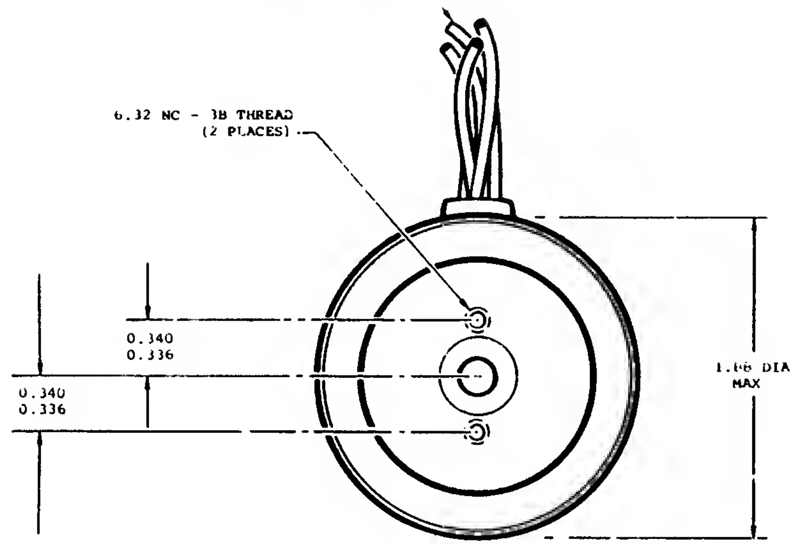
NAME	ADDRESS	TELEPHONE	OCCUPATION

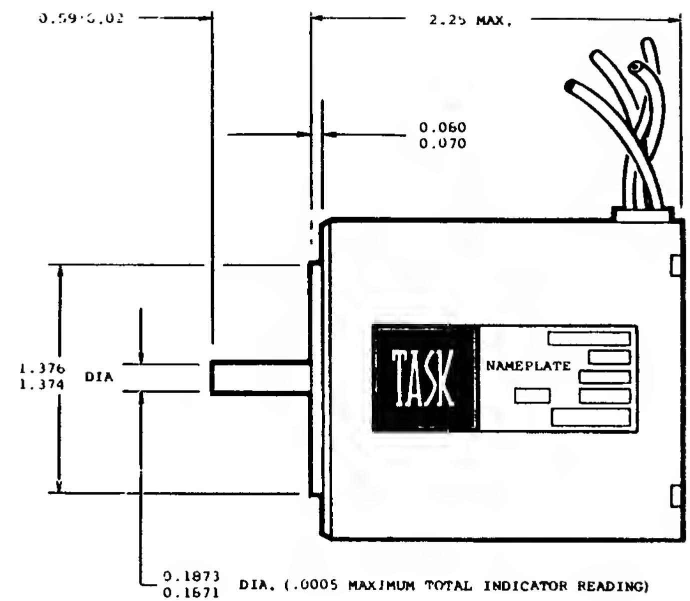
I certify that the answers given by me to the foregoing questions and statements are true and correct without consequential omissions of any kind whatsoever. I agree that the company shall not be liable in any respect if my employment is terminated because of the falsity of statements, answers or omissions made by me in this questionnaire. I agree to submit to physical examination. I also authorize the companies, schools or persons named above to give any information regarding my employment, together with any information they may have regarding me whether or not it is in their records. I hereby release said companies, schools or persons from all liability for any damage for issuing this information.

DO NOT SIGN THIS APPLICATION

FOR INTERVIEWER'S REMARKS: ______________________________

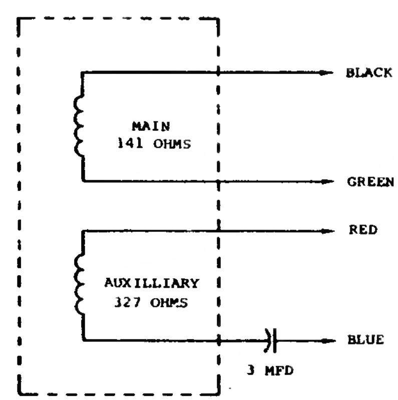
ECL 8R





SPECIFICATIONS

ELECTRICAL CHARACTERISTICS:	
VOLTAGE	115±5 VAC
FREQUENCY	60 CPS
CURRENT	0.5 AMP. MAX
MAIN RESISTANCE	141 OHMS
AUXILIARY RESISTANCE	327 OHMS
CAPACITOR (EXTERNAL)	3 MFD
OPERATING CHARACTERISTICS:	
SYNCHRONOUS SPEED	1800 RPM
TORQUE (100°F MOTOR TEMPERATURE):	
CONTINUOUS	6 OZ.IN. MIN.
PULL-IN	2 OZ.IN. MIN.
PULL-OUT	8 OZ.IN. MIN.



WIRING SCHEMATIC

ROTATION AS VIEWED FROM SHAFT END:

CCW - CONNECT BLACK TO BLUE AND RED TO GREEN
CW - CONNECT BLACK TO RED AND GREEN TO BLUE

P/N 4978-2 SYNCHRONOUS ELECTRIC MOTOR

TRANSDUCER PRODUCTS

Simple Elastic Pivots

TASK

SC — TWO DEGREES OF FREEDOM; COINCIDENT CENTERS

SCT — THREE DEGREES OF FREEDOM; COINCIDENT CENTERS

TYPE

INHERENT FEATURES OF FLAT STRAP (RIBBON) FLEXURES

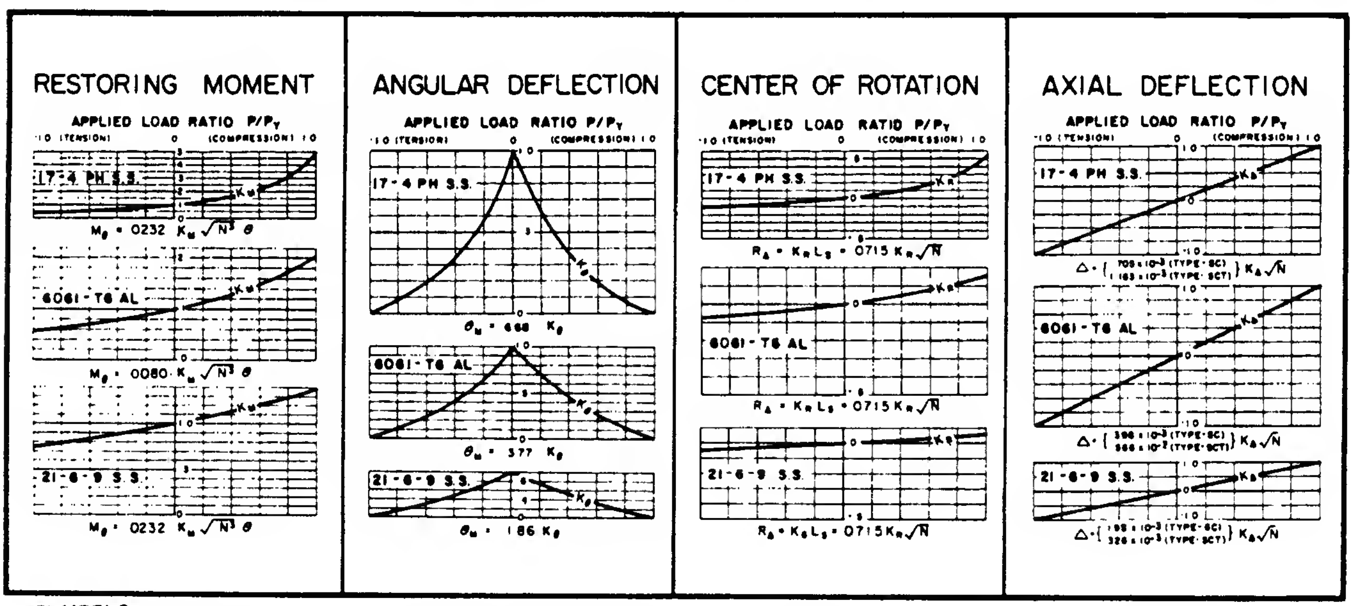
- MODERATE ALLOWABLE BENDING DEFLECTIONS
- MODERATE RESTORING MOMENT VARIATION
- MODERATE SHIFT OF CENTER OF ROTATION
- LOW LATERAL LOAD CAPACITY
- MODERATE AXIAL STIFFNESS
- LOW RESTORING MOMENT

ENGINEERING DATA

THE RESTORING MOMENT (LB.-IN.), MAXIMUM ALLOWABLE ANGULAR DEFLECTION (DEG.), SHIFT OF POSITION OF THE CENTER OF ROTATION (IN.), AND AXIAL DEFLECTION (IN.), EACH VARY WITH THE RATIO OF APPLIED LOAD TO YIELD LOAD CAPACITY (P/P_Y).

THE FORMULAE FOR EACH OF THESE QUANTITIES ARE PRESENTED BELOW EACH OF THE PLOTTED CURVES. THE FACTORS (K_M, K_θ, K_R, AND K_Δ, RESPECTIVELY) EXPRESSING THE VARIATION WITH APPLIED LOAD RATIO ARE PLOTTED FOR EACH OF THREE REPRESENTATIVE MATERIALS.* IN EACH COLUMN OF THREE PLOTS, THE SCALES ARE CHOSEN TO ILLUSTRATE THE RELATIVE MAGNITUDE OF MOMENT (OR ALLOWABLE ANGLE, OR SHIFT OF CENTER OF ROTATION, OR DEFLECTION) FOR ELASTIC PIVOTS OF EQUAL LOAD CAPACITY.

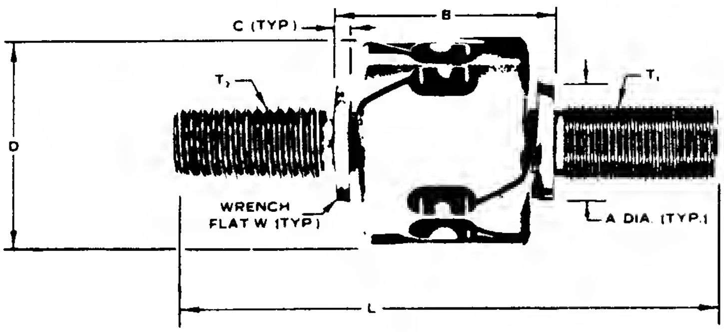
THE PIVOT INDEX (N) IS A FUNCTION OF AREA AND EQUALS THE NUMBER OF POUNDS APPLIED LOAD TO PRODUCE 1,000 PSI AXIAL STRESS. THE CURVES PRESENTED BELOW ARE BASED ON A YIELD STRESS (σ_Y) OF 180,000 PSI FOR 17-4 PH STAINLESS STEEL, 35,000 PSI FOR 6061-T6 ALUMINUM, AND 50,000 PSI FOR 21-6-9 STAINLESS STEEL.



SYMBOLS

- M_Θ — RESTORING MOMENT (LB.-IN.)
- Θ_M — ANGULAR BENDING DEFLECTION (DEG.)
- R_Δ — SHIFT OF POSITION OF CENTER OF ROTATION (IN.)
- Δ — AXIAL DEFLECTION (IN.)
- N — INDEX (LB./1,000 PSI)
- L_S — LENGTH OF FLEXURE STRAP (IN.)
- P — APPLIED LOAD (POUNDS)
- P_Y — YIELD LOAD (POUNDS)

* NOTE: 21-6-9 SS IS NOT OFFERED AS A STANDARD ELASTIC PIVOT MATERIAL, BUT IS INCLUDED AS AN EXAMPLE OF AN AUSTENITIC STAINLESS STEEL.

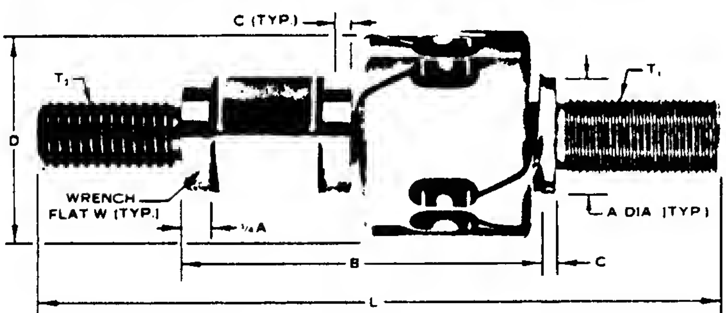


TYPE **SC**

INDEX								THREAD	
NOM. SIZE	LB/1000 PSI	A	B	C	D	L	W	T_1	T_2
1/2	5.00	.250	.510	.040	.490	1.17	.187	NO.8–36 NF	NO.8–32 NC
5/8	8.00	.312	.640	.050	.615	1.40	.250	NO.10–32 NF	NO.10–24 NC
3/4	12.50	.375	.790	.060	.740	1.79	.312	1/4–28 NF	1/4–20 NC
1	20.00	.500	1.020	.075	.990	2.26	.375	5/16–24 NF	5/16–18 NC
1–1/4	32.00	.625	1.280	.095	1.235	2.78	.500	3/8–24 NF	3/8–16 NC
1–1/2	50.00	.750	1.580	.115	1.485	3.58	.625	1/2–20 NF	1/2–13 NC
2	80.00	1.000	2.050	.150	1.985	4.55	.750	5/8–18 NF	5/8–11 NC
2–1/2	125.00	1.250	2.550	.190	2.485	5.55	1.000	3/4–16 NF	3/4–10 NC
3	200.00	1.500	3.150	.225	2.980	7.15	1.250	1 – 14 NF	1 – 8 NC
4	320.00	2.000	4.100	.300	3.980	9.10	1.500	1 1/4–12 NF	1 1/4–7 NC
5	500.00	2.500	5.100	.375	4.980	11.10	2.000	1 1/2–12 NF	1 1/2–6 NC
6	800.00	3.000	6.300	.450	5.980	12.30	2.500	2 – 8 (F)	2 – 4 1/2 NC
8	1,250.00	4.000	8.200	.600	7.980	15.70	3.000	2 1/2–8 (F)	2 1/2–4 NC
10	2,000.00	5.000	10.200	.750	9.980	19.20	4.000	3 – 8 (F)	3 – 4 NC
12	3,200.00	6.000	12.600	.900	11.980	24.60	5.000	4 – 8 (F)	4 – 4 NC

THE TYPE SC TASK ELASTIC PIVOT PROVIDES BI – ROTATIONAL FREEDOM, OR UNIVERSAL JOINT ACTION, WITH COINCIDENT CENTERS OF ROTATION FOR APPLICATIONS REQUIRING MODERATE ANGULAR DEFLECTION AND HIGH COMPLIANCE (LOW RESTORING MOMENT). EACH FLEXIBLE PORTION OF THIS COMPACT "FOLDED" CONFIGURATION IS A STRAIGHT-SIDED STRAP OF RECTANGULAR CROSS-SECTION WHOSE LENGTH IS LIMITED ONLY BY COLUMN STABILITY REQUIREMENTS.

THIS PIVOT IS OFFERED AS STANDARD IN THE SIZES SHOWN AT LEFT IN EITHER 17-4 PH STAINLESS STEEL OR 6061-T6 ALUMINUM. IN THESE MATERIALS AND SIZES, STOPS ARE PROVIDED TO PREVENT OVERSTRESSING DUE TO EXCESSIVE ANGULAR DEFLECTION.



TYPE **SCT**

INDEX								THREAD	
NOM. SIZE	LB/1000 PSI	A	B	C	D	L	W	T_1	T_2
1/2	5.00	.250	.880	.040	.490	1.54	.187	NO.8–36 NF	NO.8–32 NC
5/8	8.00	.312	1.100	.050	.615	1.86	.250	NO.10–32 NF	NO.10–24 NC
3/4	12.50	.375	1.360	.060	.740	2.36	.312	1/4–28 NF	1/4–20 NC
1	20.00	.500	1.750	.075	.990	2.99	.375	5/16–24 NF	5/16–18 NC
1–1/4	32.00	.625	2.190	.095	1.235	3.69	.500	3/8–24 NF	3/8–16 NC
1–1/2	50.00	.750	2.720	.115	1.485	4.72	.625	1/2–20 NF	1/2–13 NC
2	80.00	1.000	3.500	.150	1.985	6.00	.750	5/8–18 NF	5/8–11 NC
2–1/2	125.00	1.250	4.370	.190	2.485	7.37	1.000	3/4–16 NF	3/4–10 NC
3	200.00	1.500	5.430	.225	2.980	9.43	1.250	1 – 14 NF	1 – 8 NC
4	320.00	2.000	7.000	.300	3.980	12.00	1.500	1 1/4–12 NF	1 1/4–7 NC
5	500.00	2.500	8.750	.375	4.980	14.75	2.000	1 1/2–12 NF	1 1/2–6 NC
6	800.00	3.000	10.800	.450	5.980	16.80	2.500	2 – 8 (F)	2 – 4 1/2 NC
8	1,250.00	4.000	14.000	.600	7.980	21.50	3.000	2 1/2–8 (F)	2 1/2–4 NC
10	2,000.00	5.000	17.500	.750	9.980	26.50	4.000	3 – 8 (F)	3 – 4 NC
12	3,200.00	6.000	21.600	.900	11.980	33.60	5.000	4 – 8 (F)	4 – 4 NC

THE TYPE SCT, IN ADDITION TO THE CHARACTERISTICS ABOVE, PROVIDES A THIRD DEGREE OF FREEDOM BY MEANS OF A CRUCIFORM MEMBER COMPLIANT IN TORSION. THE LENGTH OF THIS SECTION IS SUCH THAT THE TORSIONAL COMPLIANCE (AND RESTORING MOMENT) MATCH THOSE OF THE TWO ROTATIONAL DEGREES OF FREEDOM.

TASK CORPORATION

Dimensioning Test by Richard Rigney

APPENDIX I

NAME ______________________________ DATE ______________

This test is intended to indicate proficiency in arranging dimensions to meet specific design goals with minimum tolerance buildup. The objective is to dimension all the axial lengths required to meet the design goals A thru I shown on Figure 1. The nominal dimensions are given by station lines. A standard tolerance of $\pm$.010 must be used with the exception of those required to maintain goal "A"(the shaft end play held within .010-.020). The minimum number of close tolerance dimensions must be used to maintain goal "A".

All design goals are listed in their order of decreasing importance. The requirements of "A" should take precedence over "B";"C" over "D"; etc.

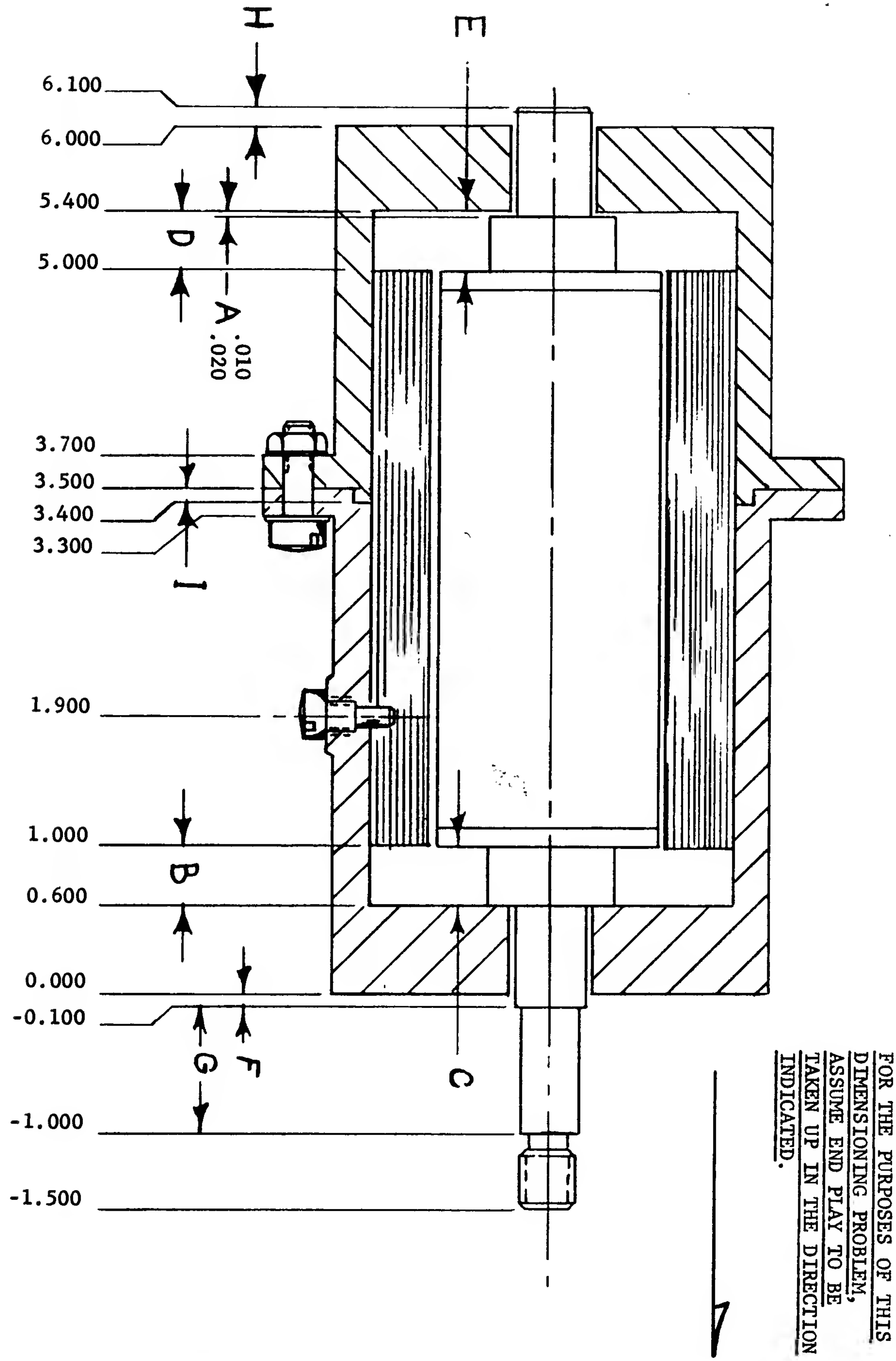
Arrange all dimensions for minimum tolerance buildup, i.e., minimum number of dimensions to locate the required surface.

Priority requirements:

1. "A" shaft end play must be held within limits shown on drawing.
2. "B" thru "H" Held to minimum buildup.
3. "I" Basic dimension as shown by layout should be modified on one or both parts to insure that one surface of the two shown will always clear the other.

Reread the above directions carefully. This examination is not intended to show proficiency in conventional dimensioning practice. The objective is to demonstrate the ability to understand and interpret directions, and to act in strict accordance with these directions. Thoroughness and attention to all details is an absolute requirement.

IT IS IMPORTANT TO FOLLOW THE INSTRUCTIONS CAREFULLY


H
E
6.100
6.000
5.400
5.000
D
A
.010
.020
3.700
3.500
3.400
3.300
I
1.900
1.000
B
0.600
0.000
-0.100
F
G
C
-1.000
-1.500
FOR THE PURPOSES OF THIS DIMENSIONING PROBLEM, ASSUME END PLAY TO BE TAKEN UP IN THE DIRECTION INDICATED.

NAME: ________

DATE: ________

Instructors' Notes

ECL 8 should prove useful for engineering instruction in several ways. First, it introduces significant topics in the realm of design procedure, and second, it actively engages the student in basic concepts of dimensioning and tolerancing. The case states that men hired by Task usually finished the test in fifteen minutes or less. Students should be given more time. We may mention that engineering teachers take up to thirty minutes to finish the test and that the majority of teachers end up with some mistakes in the part.

Discussion Topics:

1) Hiring Procedure. A Task application form is included as Exhibit 1, and is typical of those which applicants for all engineering jobs must complete. The dimensioning test (Exhibit 3) is atypical, however; few firms subject applicants to any test which is evaluated on a quantitative basis. The value of this technique might be discussed from the point of view of both the applicant and employer. Such a discussion would probably best take place after the students have attempted the test.

2) Role of Engineer in Overall Project. While Task treats its engineers as "generalists" (each man engaged in all stages of the design work for a single project) many companies develop their engineers as "specialists" responsible only for a single stage of each project. Others employ a hybrid pattern of organization, treating some men as specialists and others as generalists. Students might discuss the merits of these various systems (again from the standpoint of both employer and employee) and begin to think about their preferred role in the total design project.

3) Inspection and Testing. Students might be asked what factors influence how much testing need be performed, and if, under some circumstances, product testing could even be dispensed with. These are, of course, rather open-ended questions, which students will not be able to answer with much conclu-

siveness; the following are some general observations which might emerge from such a discussion:

a) 100% testing should be performed when lives may be endangered by a failure, but inspectors cannot do a good job of 100% inspection if very many units must be checked.
b) 100% inspection should probably be made on limited-access components (for example, in space satellites) or when cost of down-time would be critically expensive.
c) When items are mass-produced, a percentage inspection and test system is far less costly, and usually superior, unless inspection is automatic.
d) When a piece of equipment is to be used in unknown or widely-varying conditions which cannot be simulated in a laboratory, a guarantee period is sometimes used in lieu of a lengthy test program. (See ECL 40).

4) Cost per Unit Weight. Students could be asked to estimate the cost per pound of various familiar items, such as the family car, a watch, or the Surveyor spacecraft, and to relate these figures to the $60,000/lb. figure mentioned for one precision Task article. The ensuing discussion might indicate that:

a) Mass produced items (like the family automobile), usually well engineered, are inexpensive per pound, due to the high volume of sales.
b) Specialty items are far more expensive per pound, usually as a result of a much higher cost of engineering per item produced. Higher production costs, of course, also play a part.
c) Costs of engineered products can vary from about $1.00 per pound for autos and heavy equipment up to and sometimes above $100,000/lb. for ultra-precision, one-of-a-kind instrumentation and circuitry.

5) "Big-Picture" Thinking vs. Details. The class might be posed a hypothetical question such as "Who do you think is harder for a company to find, a man with really good ideas, or a man who can efficiently work out the details of a design?" (Like Les Brown in ECL 46). One of the objectives of

the Case Program is to convince students of the importance of details in engineering work. Good detail men are unquestionably harder to find and frequently more valuable than bright young engineers with great ideas. It is hoped that the early exposure to detail work in the Task Dimensioning Test will impress upon the student that challenges exist in detail work as well as in "broad-concept" design. The remarks of Mr. Ward, the President of Task Corporation, quoted at the end of the case, express this thought.

Dimensioning Test Solution:

Exhibit T-1 shows a suggested solution to the dimensioning test. Dimensions have been expressed in the "bilateral tolerance" form; that is, as a nominal dimension plus or minus an equal tolerance increment (example: 1.900 ± .002). Two alternative systems are:

1) Limits of size, specifying upper and lower size limits, such as: $\frac{1.902}{1.898}$.
2) Unilateral tolerance, specifying a tolerance increment in one direction only, as 1.902 - .004.

The first system (bilateral) seems preferable for the purpose of this test, since it contains the nominal dimension, but for the machinist the second is probably more convenient because he doesn't have to add or subtract.

Step-by-step Solution:

Letters on Exhibit T-1 correspond to the assignment goals A through H affected by that dimension.

A) The critical shaft end-play of .010 - .020" must be achieved by judicious tolerancing of parts 1, 2, and 4; there are three dimensions among which a total tolerance of .010" must be divided. Since the length dimension A on 4 appears easiest of the three to machine correctly, it has been allowed the smallest tolerance range (.002") with tolerance ranges of .004" assigned to each of the other dimensions in question.

B) This dimension is determined by alignment of the two axes for the set screw; these are located on parts 2 and 3 as shown.

C) C is influenced only by the one indicated dimension on part 4.

D) D is now determined by the length of part 3, since inside housing length is already rigidly toleranced and part 3 has been located with respect to the housing in B.

E) E can now be affected only by the length shown on part 4.

F) This dimension is determined by the housing end thickness (part 2) and the corresponding shaft section on part 4.

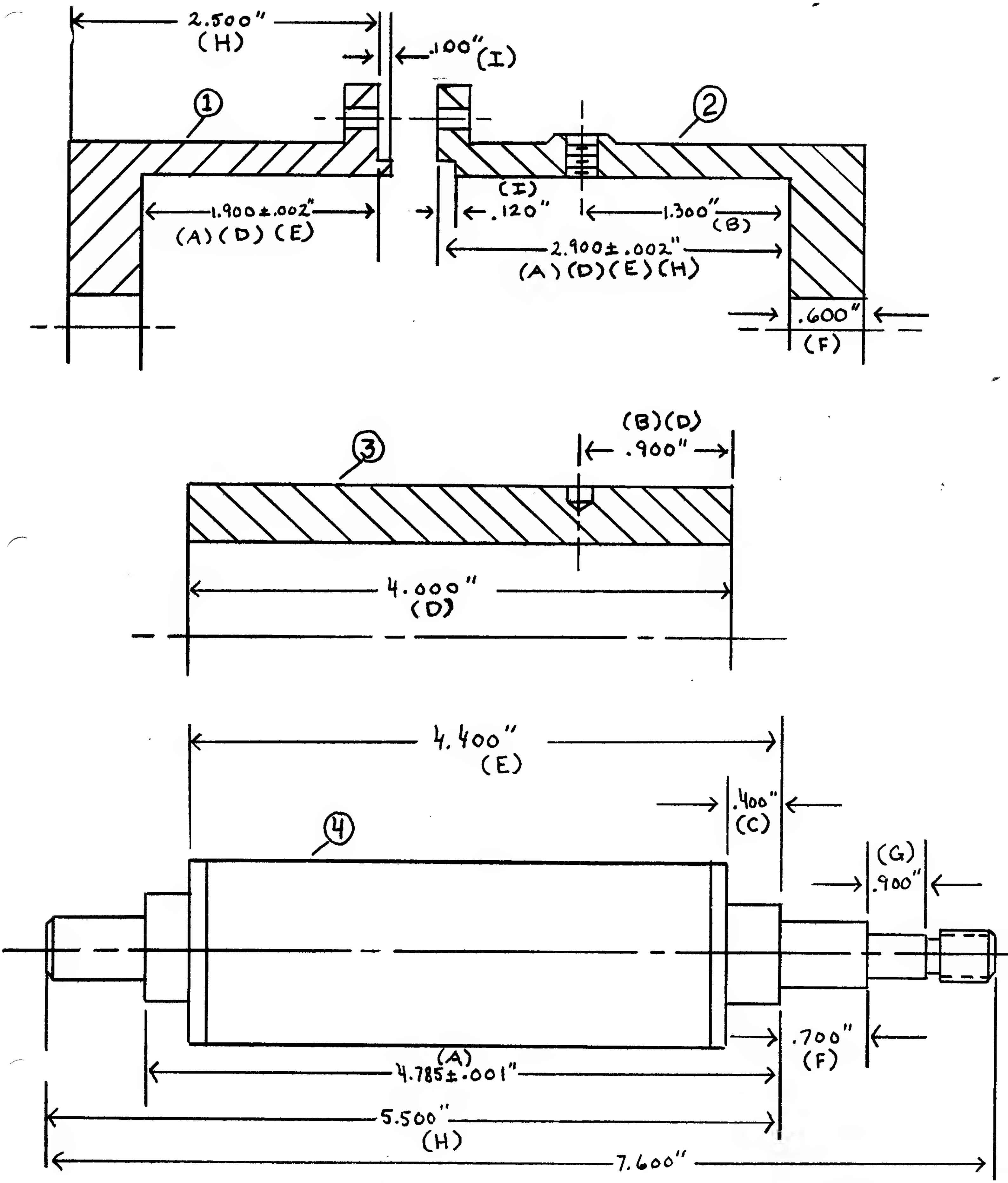
G) G stands alone.

H) H is determined by part I housing length, inside length of part 2, and rotor length (part 4) as specified in the exhibit.

I) Nominal dimension I must be adjusted to prevent interference. Using the standard tolerance ($\pm$ 0.010), clearance between the two surfaces may vary from .000 to .040".

This can be done in one of two ways as implied in the instructions; either the flange surfaces or the inner rim surfaces must always clear. At first glance it would seem wiser to insure that the inner rim does not interfere with mating of the flange surfaces; otherwise, tightening of the bolts might distort or crack the case. Measurement would be easier if the inner rim surfaces were used. In the sample solution given here, the assumption is made that case distortion would be the more serious problem. If more evidence showed this assumption to be erroneous, the critical dimensions discussed should be measured from the inner rim surface, not from the outer flange surfaces.

Exhibit T-1


2.500"
(H)
.100"
(I)
1
2
(I)
.120"
1.900±.002"
(A) (D) (E)
1.300"
(B)
2.900±.002"
(A) (D) (E) (H)
.600"
(F)
3
(B)(D)
.900"
4.000"
(D)
4.400"
(E)
.400"
(C)
4
(G)
.900"
.700"
(F)
(A)
4.785±.001"
5.500"
(H)
7.600"